Ocean-Ice Interaction beneath the Pine Island Glacier (PIG) Ice Shelf: The Key to Ice-Sheet Stability

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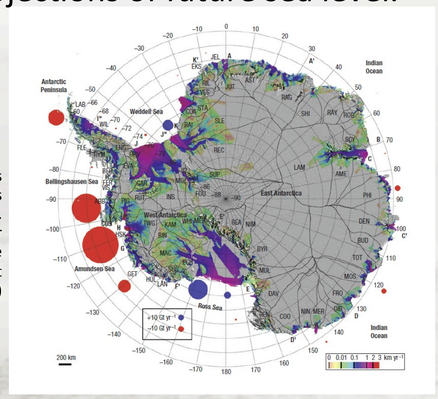
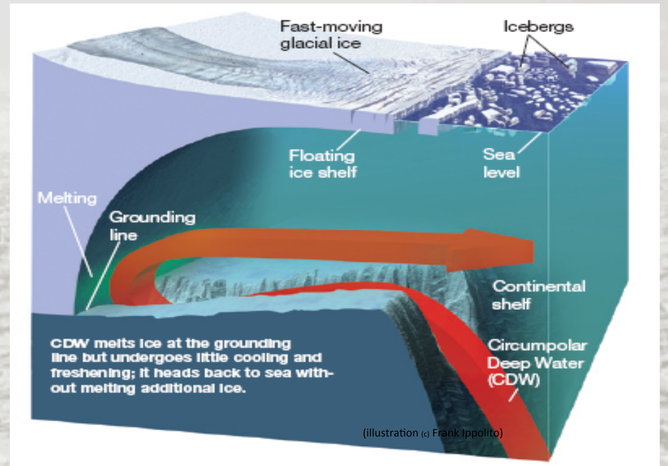
pigiceshelf.nasa.gov

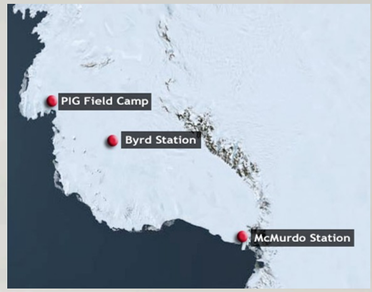
Global sea level will likely rise 1 meter by 2100 displacing 145 million people and affecting the lives of 2 billion people living in coastal areas around the world. The Intergovernmental Panel on Climate Change (IPCC) identified rapidly changing ice sheets as the main source of accelerating sea level rise, but stated poor understanding of the processes responsible for recent changes prevents accurate projections of future sea level.



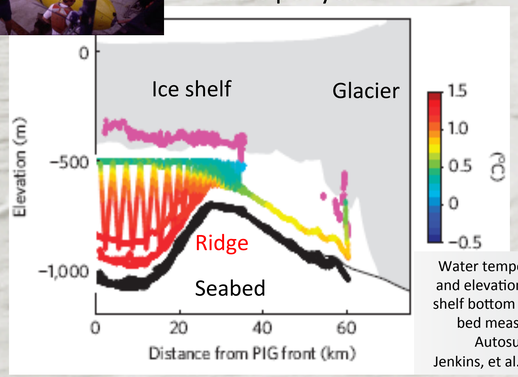
Circle size indicates rate of ice mass loss (red) or gain (blue). Color scale in lower right indicates ice speed. (from Rignot et al., 2008)

Antarctic land ice loss is concentrated along the Amundsen Sea coast of the West Antarctic ice sheet and is responsible for 7% of global sea level rise. Moving at 4000 meters per year (1.5 feet per hour!), Pine Island Glacier (PIG) is the fastest Antarctic glacier. The pattern of PIG's thinning, acceleration and retreat indicates the ocean is forcing these changes.


Fast-moving glacial ice
Icebergs
Floating ice shelf
Sea level
Melting
Grounding line
Continental shelf
CDW melts ice at the grounding line but undergoes little cooling and freshening; it heads back to sea without melting additional ice.
Circumpolar Deep Water (CDW)
(illustration (c) Frank Ippolito)



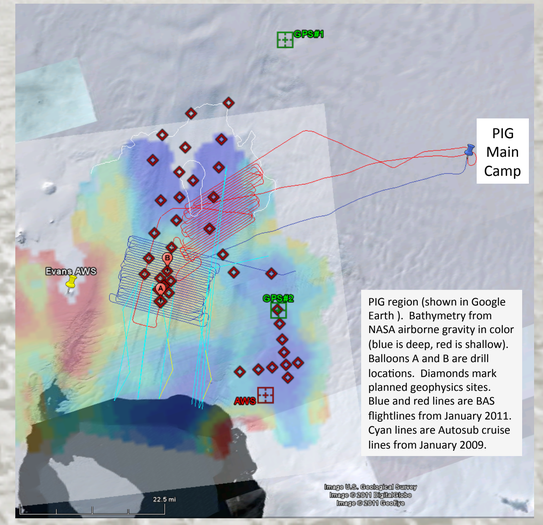
Upwelling circumpolar deep water in the Southern Ocean, forced by variable circumpolar winds washes up on the continental flows along the continental shelf until reaching the grounded glacier, causing intense basal melt in excess of 100 meters per year.



Water temperature, and elevations of ice shelf bottom and sea bed measured by Autosub (from Jenkins, et al., 2010).

First observations beneath the ice shelf in January 2009 by were made by Autosub (built by University of Southampton and operated by the British Antarctic Survey off the Nathaniel B. Palmer). Warm water and a previously unknown subglacial ridge were discovered .

Airborne gravity measurement by NASA's IceBridge mission suggest dense warm water might access the PIG by flowing around the subglacial ridge in a deep subglacial channel.


PIG Main Camp
Evans AWS
A
B
AWS
22.5 mi
PIG region (shown in Google Earth). Bathymetry from NASA airborne gravity in color (blue is deep, red is shallow). Balloons A and B are drill locations. Diamonds mark planned geophysics sites. Blue and red lines are BAS flightlines from January 2011. Cyan lines are Autosub cruise lines from January 2009.

Photographs from test drilling season at Windless Bight in November 2009.

Martin Truffer (UAF) and hot water drill

Alberto Behar (JPL) with borehole camera

Tim Stanton (r) and Jim Stockel (l) (both NPS) with ocean profiler

Planned observations in 2011-12 include oceanographic, seismic and glaciological measurements: instruments installed through holes drilled through the ice shelf will measure profiles of current, temperature and salinity in the water column to quantify the variability of warm salty water entering the sub-ice-shelf cavity, the exiting cooler, fresher water, as well as basal melting along the underside of the ice shelf. Seismic measurements located at critical bathymetric points will determine the shape of the ocean cavity to illuminate the pattern of sub-shelf water circulation. Glaciological measurements will capture the response of ice flow to changes in the water conditions. Instruments will continue measurements through the winter and be expanded during a second field season in 2012-13.

Participating institutions:
NASA (GSFC and JPL)
Naval Postgraduate School
University of Alaska, Fairbanks
Pennsylvania State University
New York University
British Antarctic Survey

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